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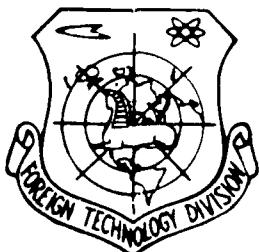
FOREIGN TECHNOLOGY DIVISION



ABRASIVE WEAR OF MATERIALS IN A BLAST FURNACE
UNDER ACTUAL WORKING CONDITIONS

by

G. P. Mel'nichenko, M. A. Tylkin, et al.



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By: G. P. Mel'nichenko, M. A. Tylkin, et al.

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ABSTRACT The purpose of this study was to det. the wear of pairs from various steel (in mutual contact as they are present in blast-furnace charging machinery) in an atm. of blast-furnace gas and dust. The tests were carried out in an industrial blast furnace, whereby the gap between the pair of materials and the angle of the gas entrance were varied. The gas and dust compns. are given in the text. The following pairs of steels were tested (1st figures for the bell, 2nd figures for the cup): 10, 10; 35, 35; 45, 45; 50G2, 50G2; 6KhV2S, 60KhV2S; 30KhGSA, 30KhGSA; R18, R18; 3Kh2V8, 3Kh2V8; 2Kh13, 2Kh13; T590, T590; T620, T620; G13, G13; U15Kh17N2, U15Kh17N2; Kh20N10G6, Kh20N10G6; 1Kh18N9T, 1Kh18N9T; U20Kh17T, U20Kh17T; 30KhGSA, T590; T590, 3Kh2V8; 1Kh18N9T, 45; and 1Kh18N9T, T590. Cast, welded-on, and forged materials, as well as materials forged, quenched, and tempered at 400 degrees, were tested for 3 consecutive days. The best erosion resistance was shown by materials which retained hardness at high temp., such as T590 and T620. Austenitic steels showed more wear than hard materials, but the former showed higher plasticity, and for this reason they can be recommended for welding onto the surfaces working under erosion wear.

ABRASIVE WEAR OF MATERIALS IN A BLAST FURNACE UNDER ACTUAL WORKING CONDITIONS

G. P. Mel'nichenko, M. A. Tylkin, V. M. Grebenik, and Yu. A. Sysuyev

Reference [1] offers data on the wear of contacting surfaces, which were obtained in laboratories from samples whose shape and dimensions not even remotely simulated real parts.

The purpose of our work is to study the wear of contacting pairs, made from various materials, in a flow of gas under conditions quite similar to the operating conditions of the charging machinery in a blast furnace.

Tests were made on one of the blast furnaces at the F. E. Dzerzhinskiy Plant. The size of the gap between the samples, the approach angle of the gas to the gap, and the cup-bell coupling profile were varied with the aid of a device whose operating principle is easily understood from Fig. 1.

To calculate the effect of gas temperature on sample wear chromel-copel thermocouples [2], joined by compensation wires with an EPP-09M electronic potentiometer, were mounted on this device. The daily mean temperature of the samples varied from 350 to 450°C. At the same time the potentiometer recorded the temperature of the blast-furnace gas in the gas vents.

The gas consisted of, %:

CO ₂	CO	N ₂	CH ₄	H ₂
14,0	28,2	55,0	0,4	2,0

Percentage of dust in the gas was, %:

SiO ₂	Al ₂ O ₃	CaO	MgO	Fe	FeO	Fe ₂ O ₃	Zn	C
7,60	3,38	7,40	1,38	31,20	16,21	35,03	0,20	4,00

The material studied was heat-treated, forged steel having various chemical compositions and alloys based on St. 6 steel (see table). The contacting surfaces could be made from the same or different material.

Tests were made on each pair of samples for twelve days. After each 24-h period the samples were taken from the device, photographed, and weighed, after which the test continued.

It was found that the character of the wear on samples representing the cup and the bell is approximately the same. If the gas jet enters at a 60° angle, maximum wear is localized near the inlet. With the passage of time wear extends along the entire surface and into the sample.

The dependence of sample wear on the length of the test is a linear dependence. Low-carbon, soft steels wore more rapidly, and also alloys, such as T590 and T620, had decreased in weight by a factor of 15 after twelve days. However, in combination with softer steels they wore more rapidly than when paired with the same brand. For example, a bell of sormite 1 combined with a cup of 35 steel wears 1.5 times faster than when both parts are made from sormite 1.

On the basis of the data obtained, we have plotted the amount of wear versus the hardness of the samples (Fig. 2).

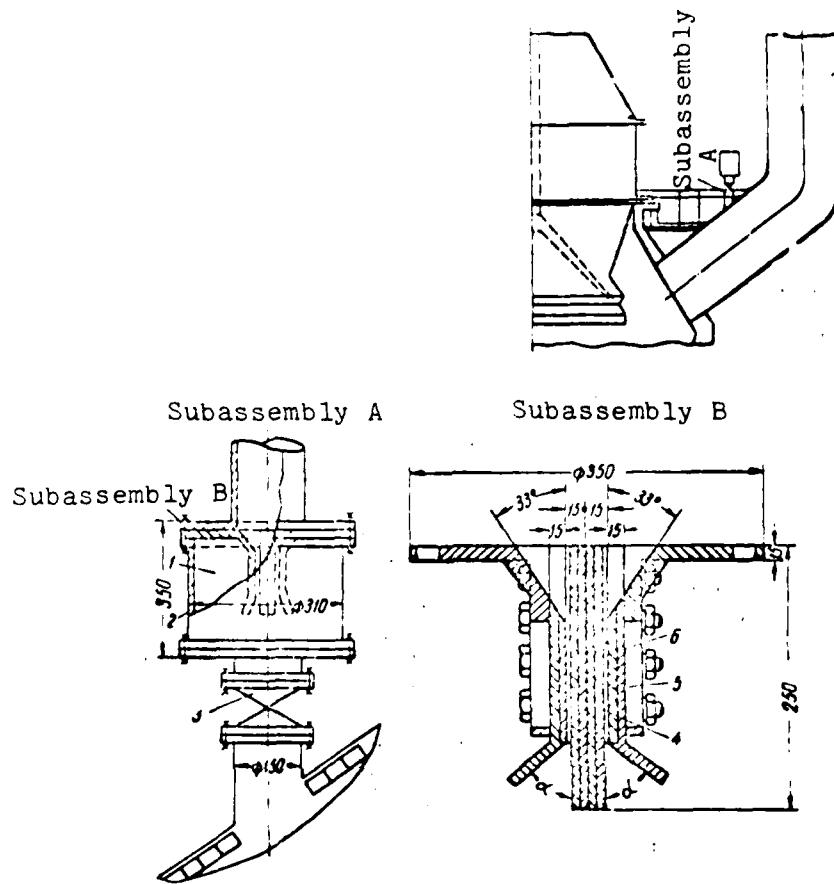


Fig. 1. Device for the wear-testing of parts in a flow of blast-furnace gas: subassembly A — mounting of device on the furnace; subassembly B — cassette assembled; 1 — cassette; 2 — working chamber; 3 — valve; 4 — 3 mm gap; 5 — generating line of the bell; 6 — generating line of the cup.

For parts with a ferrite + carbide phase state and hard alloys, the variation in wear is expressed as a hyperbolic function (Fig. 2, Curve 1). For austenitic steels with hardness from 200 to 500 HB, wear remains virtually constant. This peculiarity in the abrasion resistance of austenitic steels can be explained by the surface cold-hardening of their abrasive particles. As is known, austenitic steels harden more than other steels mainly because part of the austenite becomes martensite.

Thus, of all the studied alloys, those possessing high hardness at elevated temperatures (T590, T620) have the best resistance to

erosive wear (Fig. 3). The resistance of alloys T590 and T620 is 1.8 times higher than the resistance of sormite 1 which is widely used for welding.

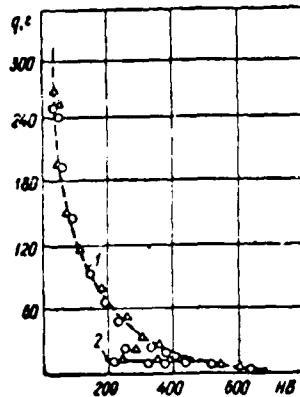


Fig. 2. Losses in sample weight (q) as a function of their hardness: 1 - martensitic steels; 2 - austenitic steels; \circ - cup hardness; Δ - bell hardness.

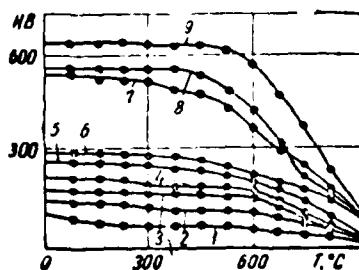


Fig. 3. Variation in sample hardness as a function of test temperature: 1-4 - steel 10, 15, 35, 65, respectively; 5 - 1Kh18N9T; 6 - 30KhGSA; 7 - sormite 1; 8 - 3Kh2V8; 9 - T590.

Austenitic steels wear more than hard alloys; however, they have high plasticity. Because of this, highly alloyed austenitic steels can be recommended for facing surfaces operating in abrasive conditions.

Table. Wear in samples representing the coupling of a bell with a cup in an active blast furnace.

Material	κ	η	Treatment	HB	K				Losses in one weight, g				Periods	Total	
					I	II	III	IV	I	II	III	IV			
					Total				Total						
10	10	94	39.34	46.84	48.36	48.54	182.92	37.02	47.22	49.34	45.41	179.20			
35	35	152	26.10	38.52	28.00	29.30	121.90	27.19	30.16	29.76	29.44	116.53			
45	45	174	26.64	32.16	26.11	27.16	111.10	23.60	26.43	23.14	25.35	98.23			
50G2	"062	197	24.15	30.65	23.25	26.30	104.35	20.35	24.80	19.49	23.44	83.23			
50Z2	50G2	551	10.35	17.40	10.70	11.25	50.70	9.15	15.21	10.01	10.45	41.52			
60G725	60N725	222	19.81	22.15	15.45	19.02	76.43	22.40	12.17	17.35	16.35	65.17			
60N725	60N725	666	8.20	11.40	9.2	10.39	39.15	9.85	11.72	10.28	8.16	40.01			
30N734	30N734	261	20.30	28.10	16.17	18.12	82.69	19.52	23.70	18.45	17.35	79.02			
R16	R16	551	2.01	3.10	3.12	3.42	2.71	2.99	3.06	3.36	3.34	16.21			
3Kh2V8	3Kh2V8	551	4.27	5.35	3.75	3.98	17.35	3.75	4.60	4.90	4.90	15.21			
2Kh13	2Kh13	341	8.45	11.15	10.57	12.16	42.7	9.44	12.60	11.50	11.50	45.21			
Sorbie 1	Sorbie 1	1	H	H	3.59	3.87	2.41	2.82	13.24	3.03	3.53	2.80	13.27		
2	7590	2	H	H	8.44	9.61	10.12	10.36	38.36	10.70	11.12	10.42	12.55		
7590	T620	H	H	H	1.45	2.60	2.21	1.76	8.01	1.36	1.61	1.61	41.79		
To-40	To-40	H	H	H	587	587	2.64	3.20	3.25	3.90	12.39	2.41	2.20	3.04	1.93
G13	G13	J	J	J	222	5.93	4.40	4.23	3.85	18.43	5.13	4.95	4.45	3.22	
U15Kh17R2	U15Kh17R2	401	423	4.30	6.25	6.75	4.17	21.47	4.53	5.81	5.81	5.23	19.63		
Kh20NiCr6	Kh20NiCr6	H	H	H	347	330	5.35	4.70	4.15	3.30	4.16	3.96	3.54	3.50	
1Kh18Ni7	1Kh18Ni7	H	H	H	249	7.20	9.15	7.60	7.75	31.70	8.49	9.91	6.85	7.63	
U24Kh17	U24Kh17	H	H	H	468	4.21	5.17	4.01	3.47	4.00	4.20	3.84	2.67	15.69	
10	Sorbie 1	10	H	H	94	587	53.35	51.40	65.10	57.30	229.70	3.31	5.00	5.50	18.29
35	30Kh5A	7590	H	H	152	587	32.13	28.41	29.36	27.40	117.32	5.85	4.67	4.75	20.54
7590	3Kh2V8	H	H	H	269	606	30.40	34.21	37.32	124.66	9.45	10.06	12.20	41.97	
45	1Kh18Ni7	1Kh18Ni7	H	H	606	551	2.69	3.22	3.35	4.97	14.23	6.79	7.45	6.36	25.34
10.18197	T590	T590	H	H	131	250	15.85	21.72	18.41	14.39	68.76	24.31	24.35	30.11	26.73
					606	18.17	24.34	20.40	22.20	81.91	8.12	6.95	7.43	8.65	31.45

Note: 1. κ — bell; η — cup; Π — forged piece; $\Pi(3)$ — welded piece, Π — hardened and tempered at 400°C. 2. Each period lasted three days.

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